Fermilab Radioactive Source Training

ESH&Q Section

Course # FN000048

Introduction

- Radiological Worker Training including Radiological Worker Training Practical Factors are prerequisites for Radioactive Source Training.

- The Fermilab Radioactive Source Control and Accountability Program allows Fermilab to meet the needs of experiments, protect the health and safety of employees and experimenters, and assures compliance with DOE regulations.

- The Fermilab Radioactive Source Control Program is described in the Fermilab Radiological Control Manual, Chapter 4, Part 3.

Introduction

- This training describes the Fermilab radioactive source control program, common configurations of sources used at Fermilab, review of ALARA concepts, source inventory number system, Source Monitor responsibilities, and radioactive source controls and policies.

- Radioactive sources are also referred to as “sealed sources,” so both terms are used at Fermilab.

Introduction

- The Fermilab Radioactive Source Program is administered by the ESH&Q Section.

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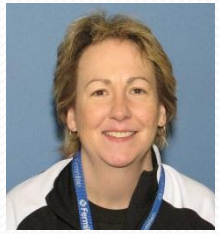

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Source Technician Backup: Dan Curatolo
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Objectives

- Identify three common source configurations used at Fermilab.
- Review ALARA, radiation exposure reduction principles, and units of radioactivity.
- Explain each portion of the source inventory number (source ID).
- Identify Fermilab Source Monitor responsibilities and procedures for proper use of source box keys.
- Identify Fermilab policies for proper and safe source use.

Common Configurations of Sources Used at Fermilab

The following source configurations are commonly used at Fermilab.

- Beta gun
- Disk
- Wand
- Plastic check sources – usually 1 inch in diameter

Beta Gun

- Srontium-90 or Ruthenium-106 source installed in a brass holder.
- Beta gun has a shutter mechanism on the top of the gun. When the shutter is pushed down, it is open; betas come out the collimated opening at the front end.
- When the shutter is released, it is closed; betas are shielded.
- Be aware that Bremsstrahlung X-rays may be produced from betas interacting with the brass holder.

Ruthenium-106 Source in Beta Gun

Disk Configuration

- Iron-55, Srontium-90, Ruthenium-106, and Americium-241 are commonly housed in 2 inch diameter aluminum disks.
- There is a cover attached to the disk that should be used when the source is being stored.
- When putting the cover on the disk, do not crimp the wire that attaches the source ID tag to the disk. If you notice damage to the wire, please notify the ESH&Q Section Source Physicist or Source Technician.

Iron-55 Source Installed in a Disk

Wand Configuration

- Higher energy gamma emitters such as Cesium-137, Cobalt-60, and Sodium-22.
- Delivered in a brass shielded container called a pig. Sealed source should remain in the brass shield during storage and transport to location of use.

Cesium-137 Wand Source

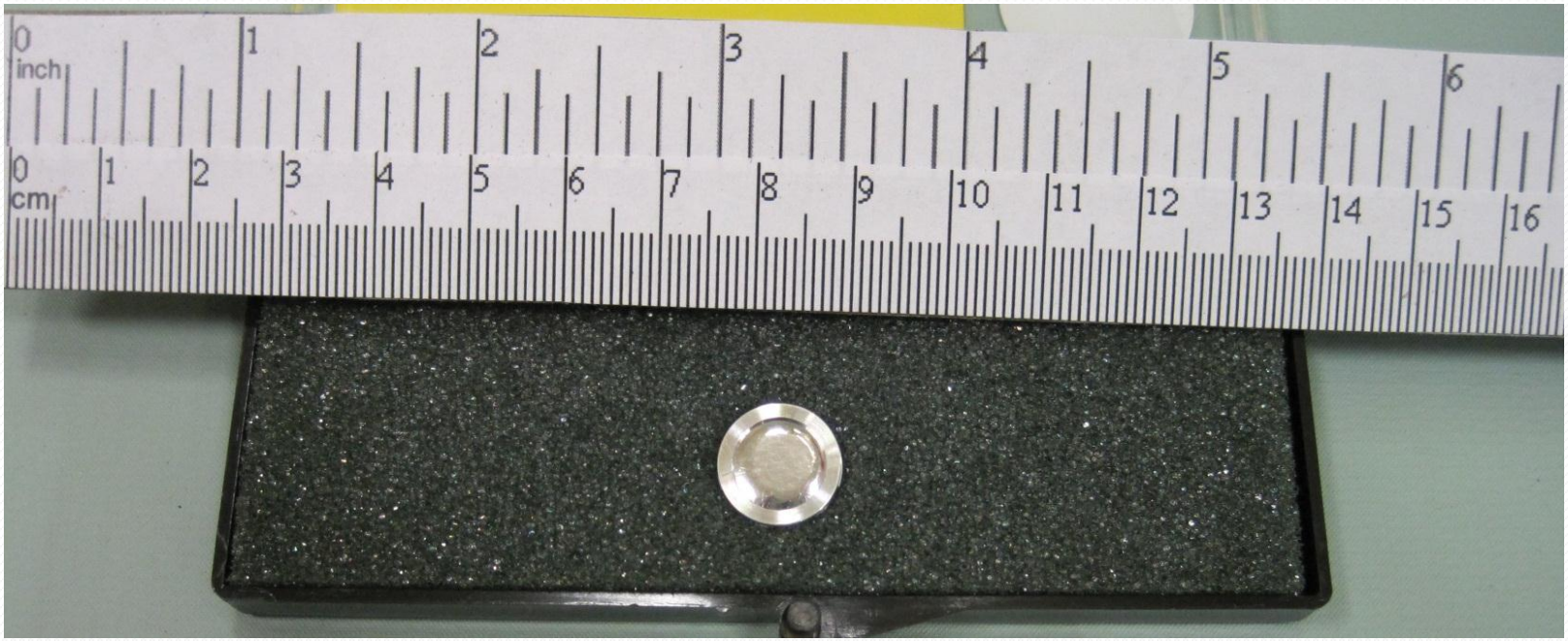
Cesium-137 Plastic Check Source

Alpha-Emitting Sources

- Caution must be taken when handling alpha-emitting sources because they are not sealed. Because alpha-emitting sources are open, they have the potential to cause contamination. Examples of alpha-emitting sources are Americium-241, Polonium-210, and Radium-226.

- Never touch the surface of the source material. Handle these sources with extreme care.

Americium-241 Source Capsule



Common Isotopes and Emissions of Sources Used at Fermilab

Isotope	Name	Atomic No.	Atomic Weight	Emission Type	Energy (MeV)	Half Life (Years)
Am-241	Americium-241	95	241	Alpha, Gamma	5.48 a; 0.026, 0.060 g, numerous Np X-rays	432.9
Bi-207	Bismuth-207	83	207	Gamma, Internal Conversion Electrons	0.570, 1.0648 g; 0.976, 0.482, Internal Conversion Electrons	33.4
Cf-252	Californium-252	98	252	Neutron	2.4 average	2.6
Cm-244	Curium-244	96	244	Alpha	5.805	18.1
Co-57	Cobalt-57	27	57	Gamma	0.014-.706	0.7
Co-60	Cobalt-60	27	60	Gamma	1.17, 1.33	5.3
Cs-137	Cesium-137	55	137	Gamma	0.662	30.1
Fe-55	Iron-55	26	55	Gamma	0.006 (Mn X-ray)	2.7
Na-22	Sodium-22	11	22	Positron, Gamma	0.511, 1.27	2.6
Pb-210	Lead-210	82	210	Alpha, Beta	3.72 a, 0.061 b	21.0
Po-210	Polonium-210	84	210	Alpha, Gamma	5.3 a, 0.802 g	0.4
Ra-226	Radium-226	88	226	Alpha, Gamma	4.78 a, 0.186-0.601	1600.0
Ru-106	Ruthenium-106	44	106	Beta, Gamma	3.54 b (from ^{106}Rh)	1.0
Sr-90	Strontium-90	38	90	Beta	0.546 b, 2.27 b (from ^{90}Y)	28.5

ALARA and Methods of Radiation Dose Reduction

- ALARA stands for As Low As Reasonably Achievable. It is a radiation safety principle for keeping radiation exposures as low as reasonably achievable.

- Use time, distance, and shielding to keep exposures ALARA when handling sealed sources.

ALARA and Methods of Radiation Dose Reduction

- Time: **Minimize** the time spent in the vicinity of a radioactive source.

- Distance: **Maximize** the distance between you and a radioactive source. The inverse square law applies to point sources: $1/r^2$ where r is the distance from the source. For example, if the distance is doubled between you and the source, the exposure rate is reduced by a factor of four.

ALARA and Methods of Radiation Dose Reduction

- Shielding: **Maximize** shielding. Use appropriate shielding for the type of radiation emitted from the source. Aluminum or plastic may be used for beta radiation and lead or some other high-density material may be used for gamma or X-ray radiation.

Units of Radioactivity

Radioactivity is expressed in units of either Curie (Ci) or Bequerel (Bq). Fermilab uses units of

Curie or subunits such as milliCurie ($1x10^{-3}$ Ci) and microCurie ($1x10^{-6}$ Ci).

- 1 Curie = $3.7x10^{10}$ disintegrations per second (dps).
- 1 milliCurie = $3.7x10^{7}$dps
- 1 microCurie = $3.7x10^{4}$ dps
- 1 Bequerel = 1 dps

Radioactive Source Inventory Number System

- Fermilab has a unique system of source identification. Upon arrival at Fermilab, the Source Technician assigns each source an unique inventory number (source ID).

- The inventory number is the atomic mass followed by representation of the initial radioactivity (activity) in microCuries (rounded to one significant figure). The last number is a sequential serial number denoting the number of sources of that atomic mass and activity that are in the inventory to date.

Sealed Source Inventory Number Examples

1. 90 - 3.1 - 32

   90 = Radionuclide identified by atomic mass (Srontium-90)
   3.1 = Initial activity = $1x10^{3}$ or **1,000 microCuries**
   32 = Sequential serial number

2. 137 - 0.4 - 112

   137 = Radionuclide identified by atomic mass (Cesium-137)
   0.4 = Initial activity = $4x10^{0}$ or **4 microCuries**
   112 = Sequential serial number

3. 241 (-1.2) 9

   241 = Radionuclide identified by atomic mass (Americium-241)
   (-1.2) = Initial activity = $2x10^{-1}$ or **0.2 microCuries**
   9 = Sequential serial number

Source Monitor Program

1. Source Monitors are assigned keys for designated source storage boxes.

2. If you are **not** a Source Monitor, you must contact the Source Monitor designated for the particular box containing the source that you intend to use. You should ensure that a Source Monitor will be available at the time you return the source to the source box.

3. In the event that a Source Monitor cannot be contacted, return the source to the **lower box, close the lid, and contact a Source Monitor as soon as possible.** The Source Monitor will retrieve the source, return it to the main source box, and complete the source access log.

Radioactive Source Storage Box

- The lid of the lower source box should be left **open** at all times unless a source needs to be returned to the lower box because a Source Monitor cannot be contacted.

Source Monitor Program

4. Source Monitors are responsible to ensure that their name is posted near the source box, but the Source Physicist will try to keep the list on the box current.

5. Source Monitors lock and unlock designated source boxes.

6. Source monitors are responsible for completing the Source Access Log each time a source is removed and returned to the source box. It is important to fill out the Source Access Log completely each time a source is removed and returned to a source box so that source use can be carefully tracked.

Source Monitor Program

7. Source Monitors must verify that the source user requesting a source is qualified to use sources by checking the person's Individual Training Plan for current Radiological Worker training and Radioactive Source training.

8. Source Monitors must return the source box key to the Source Physicist if they leave Fermilab or no longer need to be designated as a Source Monitor.

9. Source box keys shall **not** be duplicated. The Source Physicist coordinates duplication of keys.

Source Monitor Program

10. Source Monitors must ensure source users display a “Caution, Radioactive Material” and either “Caution, Controlled Area” or “Caution, Radiation Area” sign during source use. These signs are usually kept in source boxes.

11. Keys to source boxes should **not** be transferred to persons who are not Source Monitors. In some cases, Source Monitors may share a source box key. For example, if a source box key is kept in a key box with other keys, all Source Monitors for a particular source box may use the same key.

Sealed Source Use Controls and Policies

1. To obtain a radioactive source that is not currently located in a source storage box, contact the Source Physicist. The Source Physicist completes the radioactive source loan form and the source user reads, signs, and dates the form. The source user returns the form to the Source Physicist. The Source Technician then delivers the source to the designated source box.

2. Sealed sources with exposure rates high enough to cause Radiation Areas to exist require specific written work authorization. A Job-Specific Radiological Work Permit (RWP) usually serves as written work authorization.

Sealed Source Use Controls and Policies

3. A list of sources that cause Radiation Areas to exist is posted inside each source box. The source user should refer to this list as a reminder to determine whether the source he/she is using causes a Radiation Area.

4. Purchase requisitions for radioactive sources should be forwarded to the ESH&Q Section Source Physicist or designee for proper approval and signatures.

Sealed Source Use Controls and Policies

5. Sources and source boxes shall be accessible to ESH&Q Section personnel for monthly inventory and leak testing.

6. Do not tamper with, destroy, alter, or disassemble sources or their housing.

7. Do not remove the "Caution, Radioactive Material" label or the metal source ID tag from the source.

Sealed Source Use Controls and Policies

8. Do not leave radioactive sources unattended. Sources must be constantly attended or secured in a way that prevents unauthorized use. If you leave the area for any reason, return the source to the source box or arrange for another qualified source user to oversee the source during your absence.

Sealed Source Use Controls and Policies

9. Contact the ESH&Q Section Source Physicist if a source needs to be in continuous use for an extended period of time. Sources used for extended periods without being returned to the source box must be secured in a way that prevents unauthorized use.

10. Contact the ESH&Q Source Physicist if a source needs to be installed in equipment. The Source Technician will oversee the source installation and ensure that proper labels are attached to the equipment to identify the sources.

Sealed Source Use Controls and Policies

11. Keep radioactive sources in a designated locked source box when not in use. The source box must be labeled “Caution, Radioactive Material.”

12. Immediately notify the ESH&Q Section Source Physicist or Source Technician if a source appears to be missing.

13. Call x3131 immediately if you suspect that a source is damaged in a way that could cause contamination. Do **not** handle or allow others to handle the source. If you think you may have radioactive contamination on your body or clothes, ask someone to dial x3131 and stay where you are.

Sealed Source Posting Requirements

1. Always display a "Caution, Radioactive Material" sign near the source during use. Return this sign to the source box when source is no longer in use.

Sealed Source Posting Requirements

2. If the exposure rate from a source does **NOT** cause a Radiation Area, then post all access points where the source is used and stored as follows:

"Caution, Controlled Area"

and

"Caution, Radioactive Material"

or

"Caution, Radioactive Material Area"

Sealed Source Posting Requirements

Controlled Area Posting

Sealed Source Posting Requirements

3. A **Radiation Area** exists when the exposure rate is equal to or greater than 5 mR/hr at 30 cm (1 foot) from the source. If a source causes a **Radiation Area**:

   - All source users must wear a dosimetry badge.

   - Written work authorization such as a job-specific RWP must be in place to cover work.

Sealed Source Posting Requirements

4. All access points to the area where the source is used must be posted as “Caution, Radiation Area” **and** “Caution, Radioactive Material” or “Caution, Radioactive Material Area.”

Source Posting Requirements

5. Ropes, chains and/or stanchions may be used to post access points. When a source is returned to storage, these postings should be removed.

On-Site Source Transfers

1. The user shall contact the ESH&Q Section Source Physicist or Source Technician to arrange for on-site source transfers.

2. ESH&Q Section personnel deliver, pick up, and transport sources in government vehicles.

3. Transport of sources in private vehicles is prohibited.

On-Site Source Transfers

4. Contact the ESH&Q Section Source Physicist or Source Technician when the source is no longer needed. ESH&Q Section personnel will pick up the source and return it to ESH&Q Section storage.

5. The user may carry sources on foot from one building to another as long as the source is returned to its designated source box after use.

Off-Site Source Transfers

1. Radioactive sources shall not be brought on or taken off Fermilab site unless approved in advance by the Fermilab Senior Radiation Safety Officer (SRSO) or designee. The Fermilab SRSO is the ESH&Q Section Head.

2. To ship a source off site, contact the Source Physicist. A material move request form must be completed before the source can be shipped. The Source Technician will pick up the source, package it in accordance with Department of Transportation (DOT) regulations, and deliver it to the Fermilab Shipping/Receiving Department.

Source Policy Violations

1. If violations of source control policies occur, sources are confiscated and returned to ESH&Q Section storage. In general, Division/Section/Center Head approval is required before the sources may be reissued.

2. If repeated source use policy violations occur, the user's source use privileges may be revoked.

Questions

- If you have any questions regarding this training or other questions regarding the use of radioactive sources, please contact Kathy Graden of the ESH&Q Section at graden@fnal.gov or x4939.